PIP-II Cryomodule Overview &
650 MHz Cryomodule Development Plan

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650 MHz Cryomodule Design Advisory Meeting

23 October 2018

In partnership with:
India/DAE
Italy/INFN
UK/STFC
France/CEA/Irfu, CNRS/IN2P3

The PIP-II Project

Mission

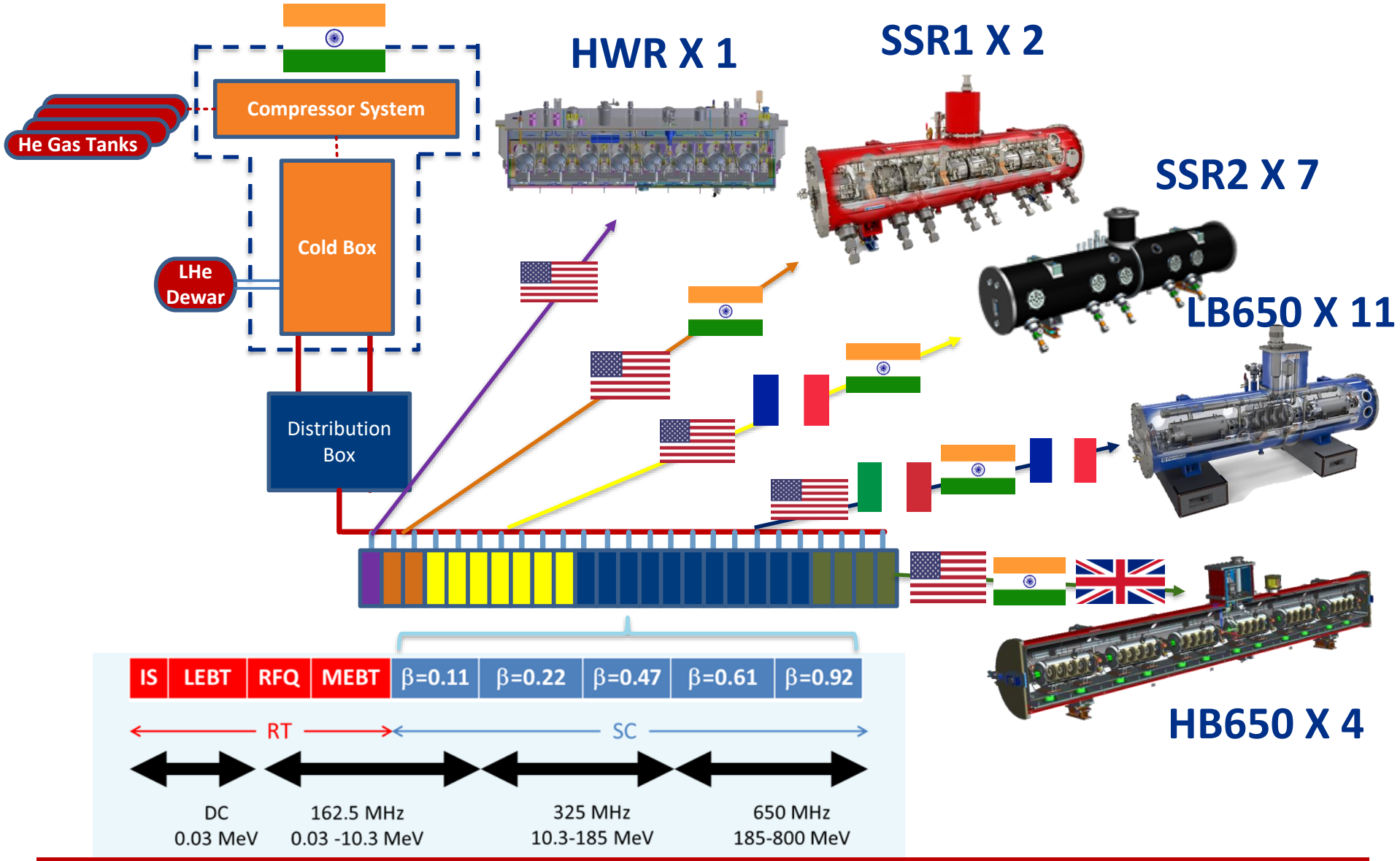
PIP-II will deliver the world's most intense beam of neutrinos to the international LBNF/DUNE project, and enable a broad physics research program, powering new discoveries for decades to come.

Goals

- Deliver 1.2 MW of proton beam power from the Main Injector over the energy range 60 – 120 GeV, at the start of LBNF ops
  - Establish a platform for future upgrades to multi-MW capability
- Provide a platform for extension of capability to high duty factor/higher beam power, multiple users and reliable operations
  - Support the ongoing 8 GeV program, including an upgrade path for Mu2e

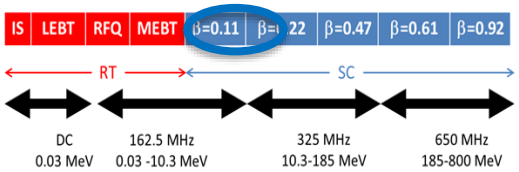
Building the world's most powerful neutrino beam

PIP-II SRF Linac & Areas of International Interest



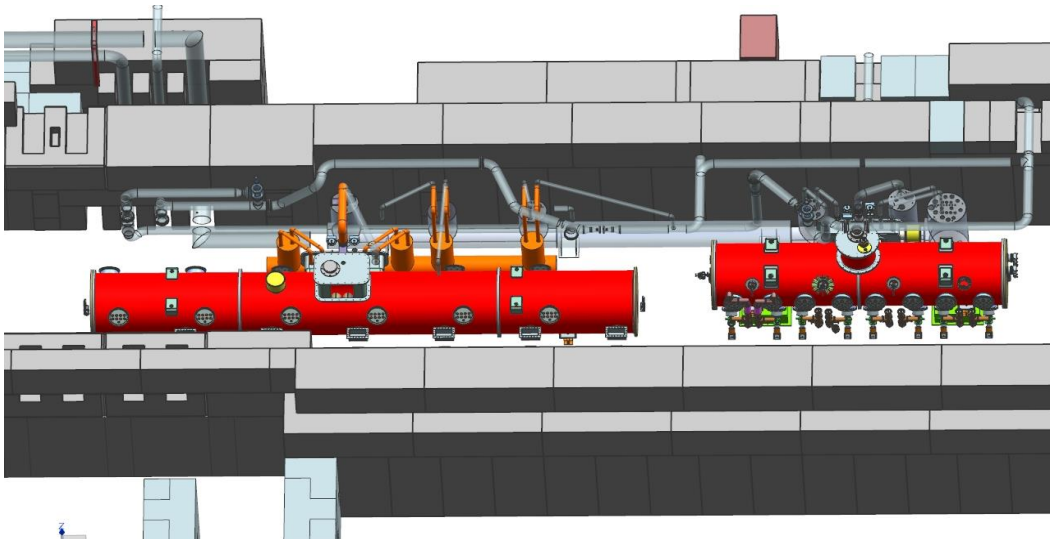
PIP-II is the first accelerator project in the U.S. with substantial international participation

PIP2IT will be repurposed to PIP-II Cryomodule Test facility



PIP2IT cave is being expanded to house HWR & SSR1

- Vertical cryo transfer line for PIP2IT was installed
- Confirmed feasibility of using PIP2IT test stand for both 650 and SSR RF testing



Cryomodules Overview

CM type	No. of CMs	Cavities Per CM	Magnets Per CM	Energy gain (MeV)	(Current) CM style	Transports
HWR	1	8	8	2	Bathtub	ANL to FNAL
SSR1	2	8	4	2.05	Strong-back	FNAL internal
SSR2	7	5	3	5	Strong-back	FNAL internal
LB650	11	3	0	11.9	Strong-back	CEA to FNAL
HB650	4	6	0	19.9	Strong-back	3: STFC to FNAL 1: FNAL internal ***
Totals:	25	116	37			

*** Prototype CM assembled at FNAL, but transport tested to STFC and back

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Trans-Atlantic shipment of ~15 650 MHz CMs

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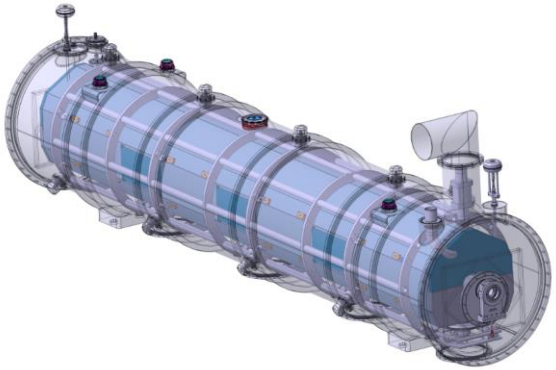
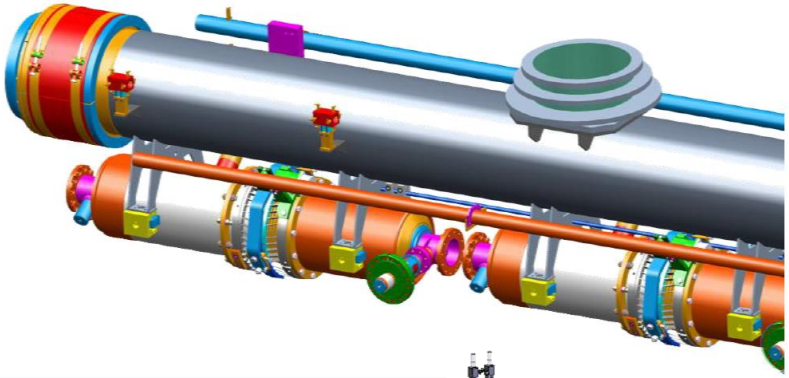
Available Designs for Cryomodule Mechanical Support

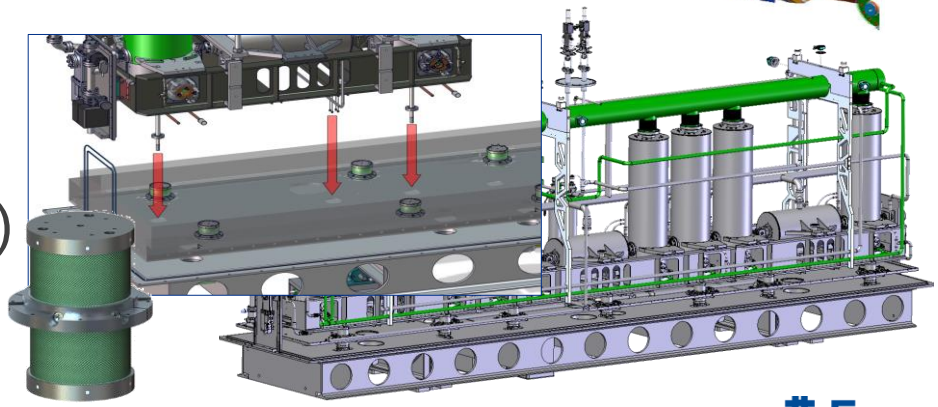
- Spaceframe Design
  - CEBAF, SNS, ESS



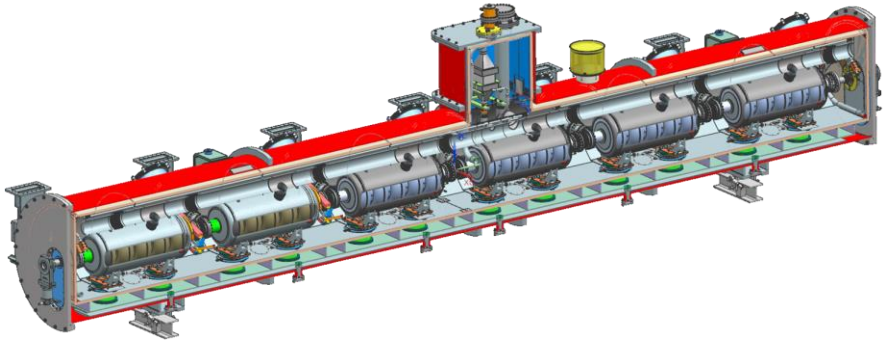
- Top Support
  - TTF, XFEL, ILC, LCLS-II

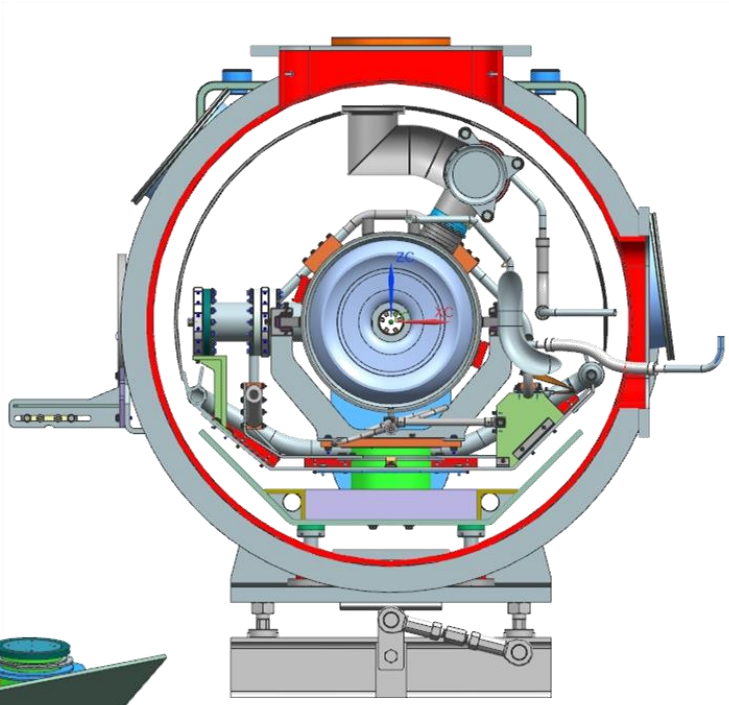


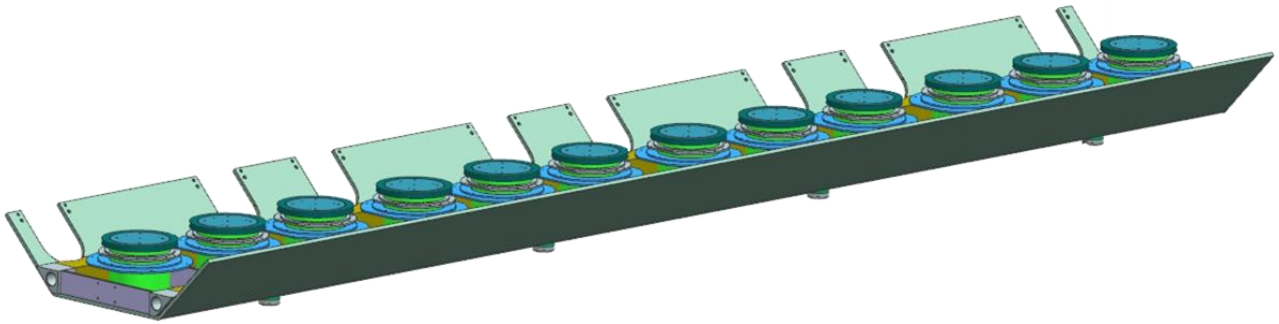
- Bottom Support
  - FRIB, PIP-II (strong back)



Alignment Configuration Concept



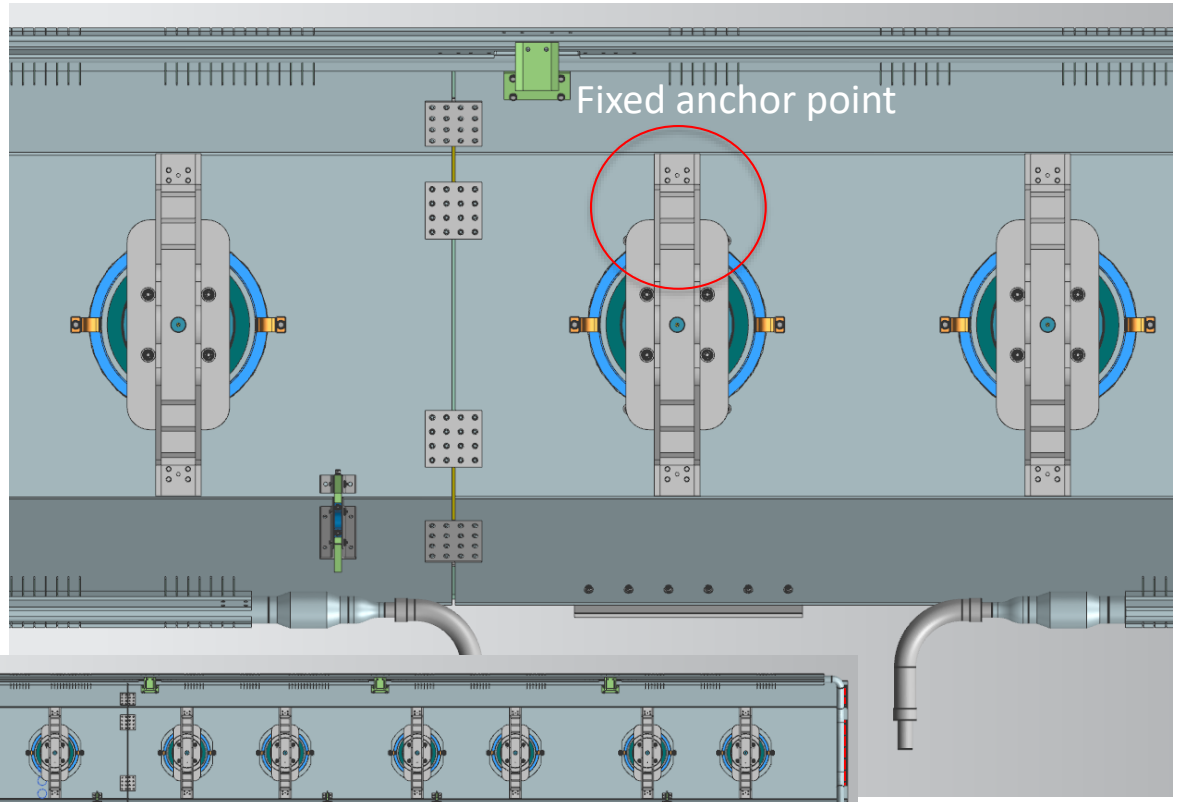


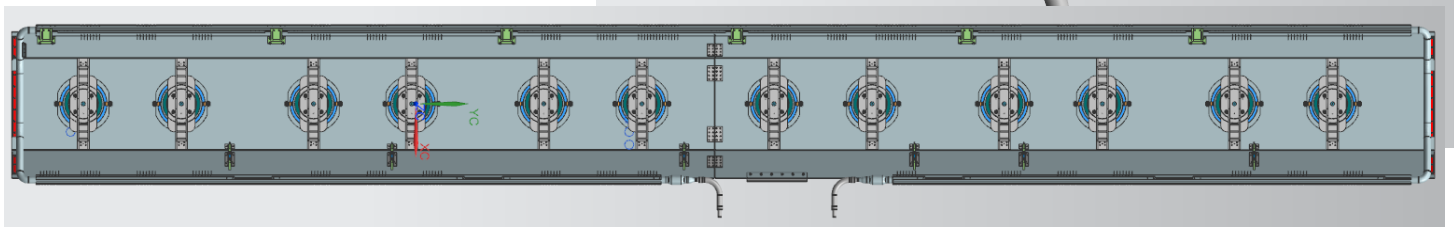


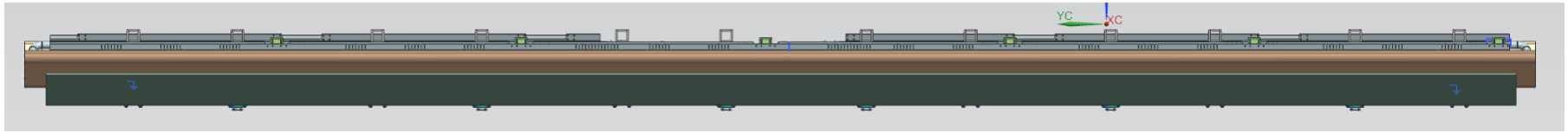
- Warm Strong back support
- Adjustable G-11 post, not accessible after assembly

Alignment Configuration Concept

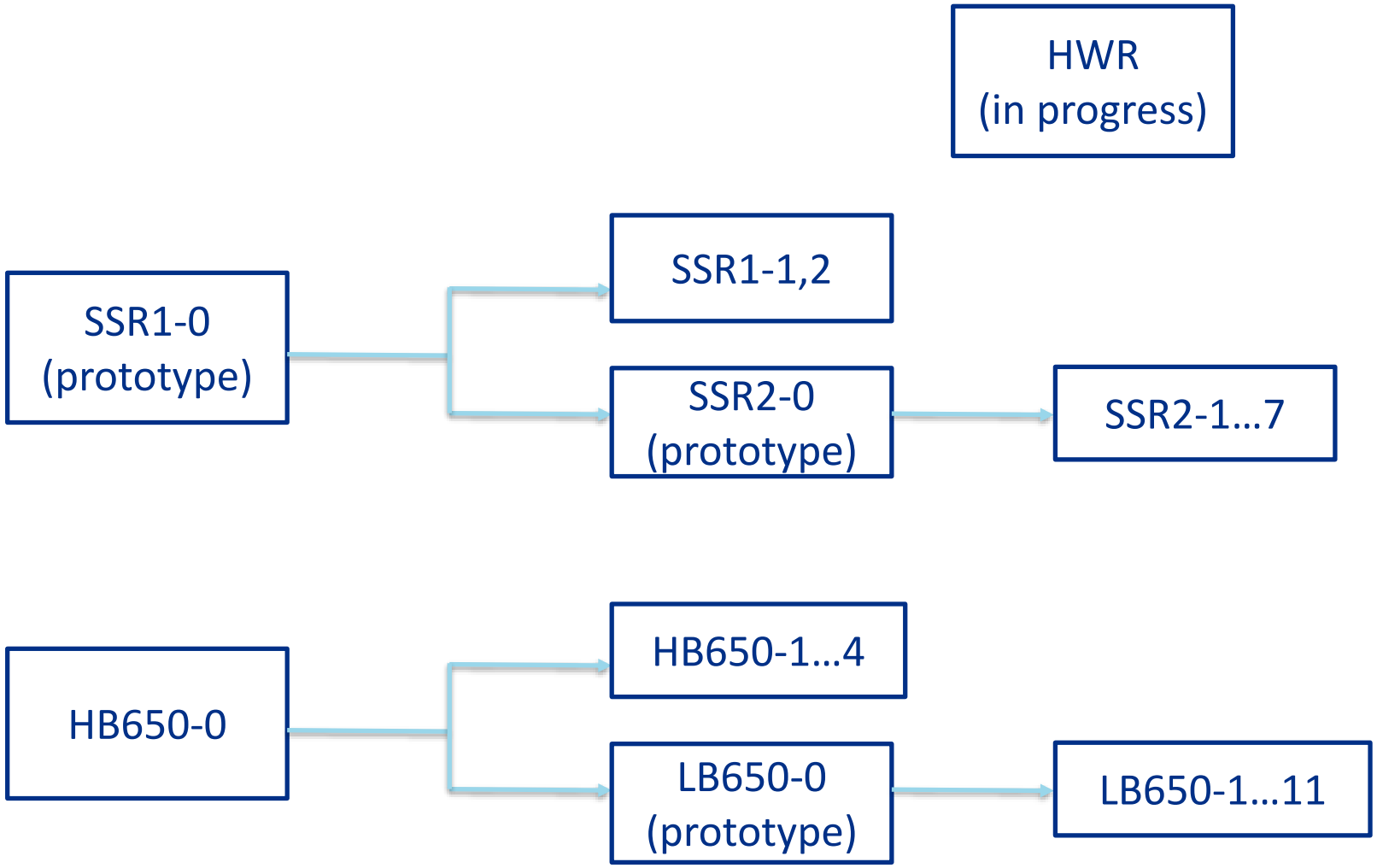
- During cool down:
- Post stays fixed
- Cavity anchor point moves nearly identical
- Dressed cavity moves nearly identical





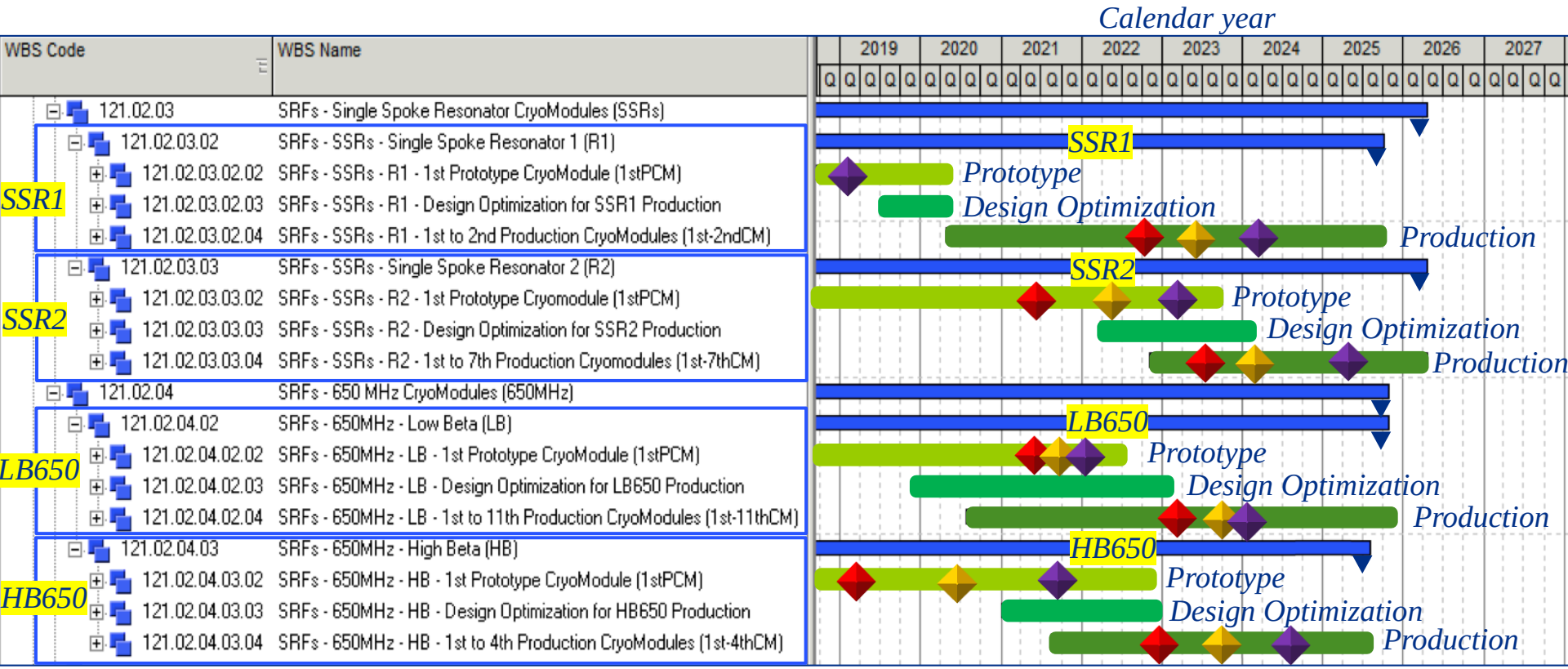


Cryomodule Development Path



DRAFT PIP-II Cryomodule Schedule

DRAFT



Legend

- Start STC tests
- Start String Assembly
- Start RF Testing

LB650 Status Overview

- Cavity RF Design completed.
- Cavity mechanical design is in progress
  - IIFC optimized the mechanical design for CW operation
- VECC started working with the INFN bare cavity design, and performing optimizations.
- Two prototypes in fabrication by INFN scheduled to arrive at Fermilab in Summer 2019

HB650 Status Overview

- Cavity RF design completed.
- Cavity mechanical design completed.
- Cavity high Q R&D is in progress.
- Dressed cavity design validation is in progress.
- Coupler design validation is in progress.
- Cryomodule design is in progress.

Status of 650 MHz CM design

- Strong-back is current baseline design of the SSR & 650 CM
- SSR1 CM design mature, and assembly soon
- SSR1 prototype CM to validate strong-back for SRF CMs
  - Expected to be approx. Q3 FY19 (Q2 CY19)
- HB650 CM design in preliminary stage
  - Design activities being performed at FNAL and RRCAT (India)
  - Some analyses performed
  - No reviews conducted yet
- LB650 CM design in preliminary stage
  - Design activities being performed at RRCAT (India)
  - No reviews conducted yet

Future 650 MHz CM design plan

- Joint design team being proposed
  - FNAL, CEA, RRCAT – CM design
  - STFC – Transportation

- Standardization of CM concept & components desired for LB650 & HB650 CMs
  - Couplers, tuners, cavity interfaces being designed to have commonality between LB & HB

- HB650 CM design may lead LB650 design in time

Today…

- Comparing strong-back & space-frame designs for trans-Atlantic transport

  - HB650 strong-back is 6-cavity, ~10 m long CM
    - ~2.5 weeks analysis time frame
    - 1st iteration of design
  - LB650 strong-back is 3-cavity, ~5 m long CM (not analyzed yet)

  - Space-frame originally designed & analyzed for SNS by JLab
  - ESS Space-frame is 4-cavity, ~6 m long CM
    - Multi-year analysis and iteration (based on report dates)